The investigation of gasification-pyrolysis of biomass in a circulating fluidized bed

G. Chen*, J. Andries, P. J. v.d. Enden, H. Spliethoff
Section Thermal Power Engineering, OCP, Delft University of Technology
Mekelweg 2, 2628 CD, Delft, the Netherlands
Fax: 0031-15-278-2460; G.Chen@wbmt.tudelft.nl

Introduction

Biomass energy is almost zero in net CO_2 emissions since carbon and energy are fixed during the biomass growth, therefore the increasing attention is being given to the use of biomass for energy generation. Gasification of biomass at present is taken as a popular technical route to produce fuel gas applied in boilers, engine, gas turbine or fuel cell. Up to now, most of researchers have focused their attentions only on fixed-bed gasification and fluidized bed gasification, at the air-blown conditions. In that case, the producer gas is simply and easily produced, however the calorific value of the gas is low, usually 2-5 MJ/Nm^3. The producer gas is also contaminated by high tar contents and particles. This type of gas if integrated with a gas turbine for a decentralized electricity production, a significant structural modification to the gas turbine have to be made to keep gas turbine operating in the designed high temperature. However, even if in this case, the system efficiency still becomes a little bit low. Furthermore, the corrosion and wear related to tar and particles carried with the producer gas can not be negligible. Circulating fluidized bed (CFB) technology, Compared with fixed bed or even fluidized bed technology, is characterized by these advantages: high heat and mass transfer intensity; high thermal capacity per unit of sectional area; relatively easy scale-up; easy control of temperature to keep the temperature profile ideal; flexibility with regard to feedrate and its composition; self-separation of particles from gas in high efficiency.

Experimental apparatus This paper presents the medium calorific value (MCV) gas production process using Miscanthus (being its ampleness in European countries) as feedstock in a laboratory-made circulating fluidized bed (CFB), with a thermal capacity of $100KW_{th}$. The CFB gasifier (CFBG) unites the pyrolysis process with the gasification process. This concept aims at improving the heating value of producer gas, up to MCV standard and also increasing the carbon conversion as well as lowering emission of NO_x, while keeping the system in a compact configuration. In detail, the CFB reactor is divided into 4 zones along the height, i.e. combustion zone, pyrolysis zone, gasification-tar-cracking zone and shift reaction zone (dependent on the end-application of the producer gas), respectively. Obviously, this CFBG system can be expected in an operation of high carbon conversion, high cold gas efficiency, low tar contents in the producer gas and particularly high gas heating value and low emissions.

Experimental investigations The subjects investigated here are:

1) The influences of operating variables, like superficial velocity, static bed material height, equivalence ratio of fluidizing agents and biomass, and the ratio of secondary/primary fluidizing agent flowrates on the quality and quantity of gas produced.
2) The effect of fuel staging (fuel stage means biomass particles will be fed into the reactor via different points along the reactor height), with a particular attention to the emission of NO_x from an after-burner which uses producer gas as fuel.
3) The effect of the biomass particle size. The first size is a laboratory-specific size, and the other is a commercial size, directly made by manufacturers.
4) The influence of nitrogen/steam injection, with a focus on the injection angles.
5) The function of a catalyst.

Modeling work Furthermore, a mathematical description of the gasification process is constructed here and the modeled results are used for a comparison with those experimentally obtained data. The model is expected to be as a basis for the optimization and scale-up of the CFBG system.